Atmosphere and Severe Weather

Chapter 9

Learning Objectives

- Understand Earth's energy balance and energy exchanges that produce climate and weather
- Know the different types of severe weather events
- Know the main effects of severe weather events, as well as their linkages to other natural hazards
- Recognize some natural service functions of severe weather
- Understand how human beings interact with severe hazards and how we can minimize the effects of these hazards

Energy

- **Understanding Energy is fundamental to understanding severe weather**
- When we experience **severe weather**, we need to remember there is a **large amount** of **energy** being **expended**
- There are **three types of Energy**
  - **Potential – stored energy**
  - **Kinetic – energy of motion**
  - **Heat – energy of random motions of atoms and molecules**

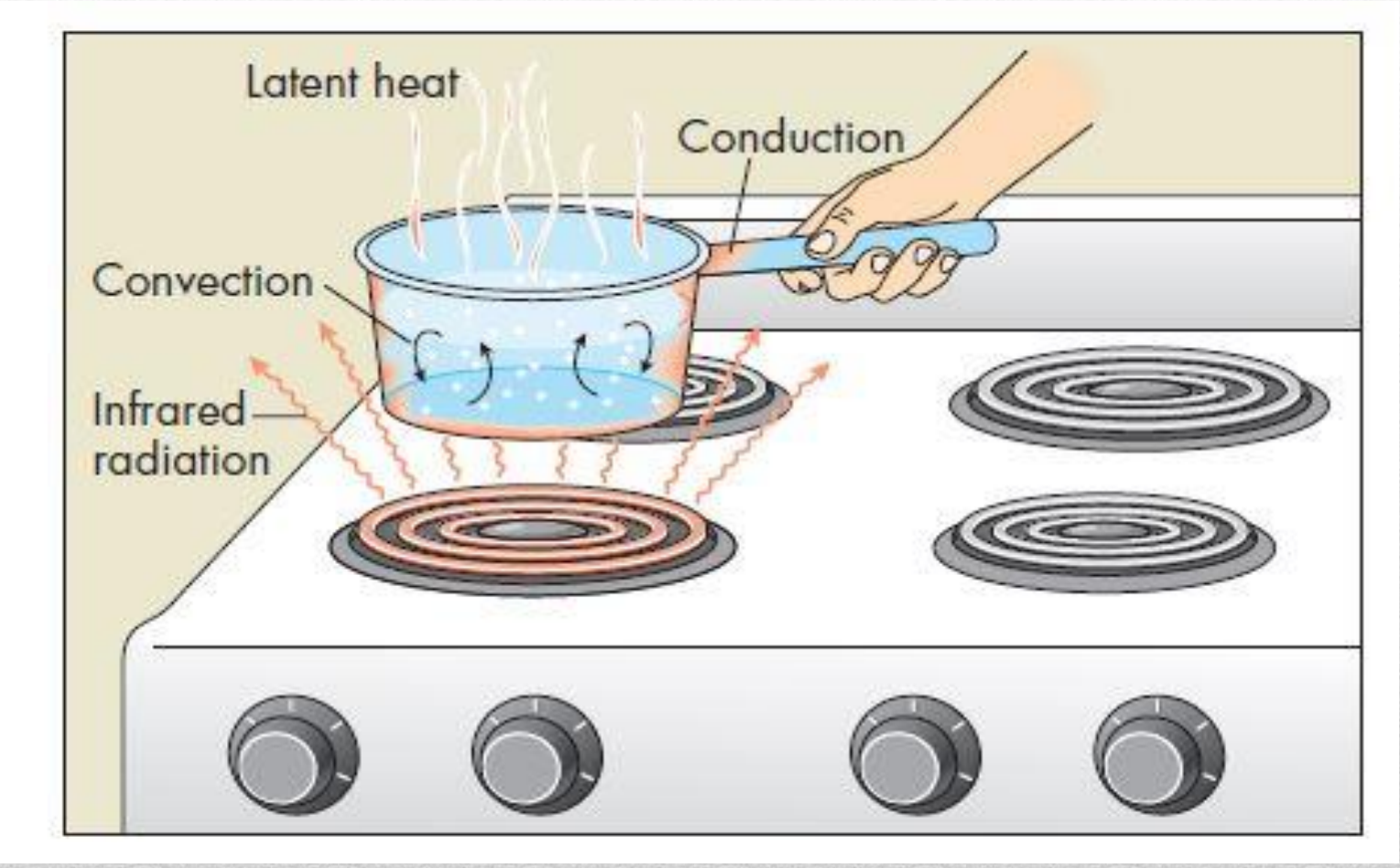
Heat

- **Heat energy** – the **kinetic** energy of atoms or molecules within a substance
- **Heat energy** – **energy** that transfers from one object to another because of the difference in **temperature**
  - The two types of **heat** that are important to atmospheric processes are ***sensible heat*** and ***latent heat***
- **Sensible heat** – heat that may be sensed or monitored by a thermometer
- **Latent heat** – heat that is either absorbed or released when a substance changes from liquid to a solid or a solid to a liquid
  - **Evaporation-** when water changes to water vapor, energy is released, cooling happens
  - **Condensation-** water vapor turns to water, energy is stored, heating happens

Heat Transfer

- **Conduction**
  - ***Conduction* relies on temperature differences,** causing heat to flow through a substance from an area of greater temperature to one of lower temperature. The atmosphere is a bad conductor of heat, where the earth and water a good conductors of heat
- **Convection**
  - ***Convection* is the transfer of heat** by the mass movement of a fluid, such as water or air. Physical mixing of heat energy in the atmosphere or water is called a *convection cell*.
- **Radiation**
  - ***Radiation* is a wavelike energy** that is emitted by any substance that possesses heat. The transfer of energy by radiation occurs by oscillations in an electric field and a magnetic field are called *electromagnetic waves.*

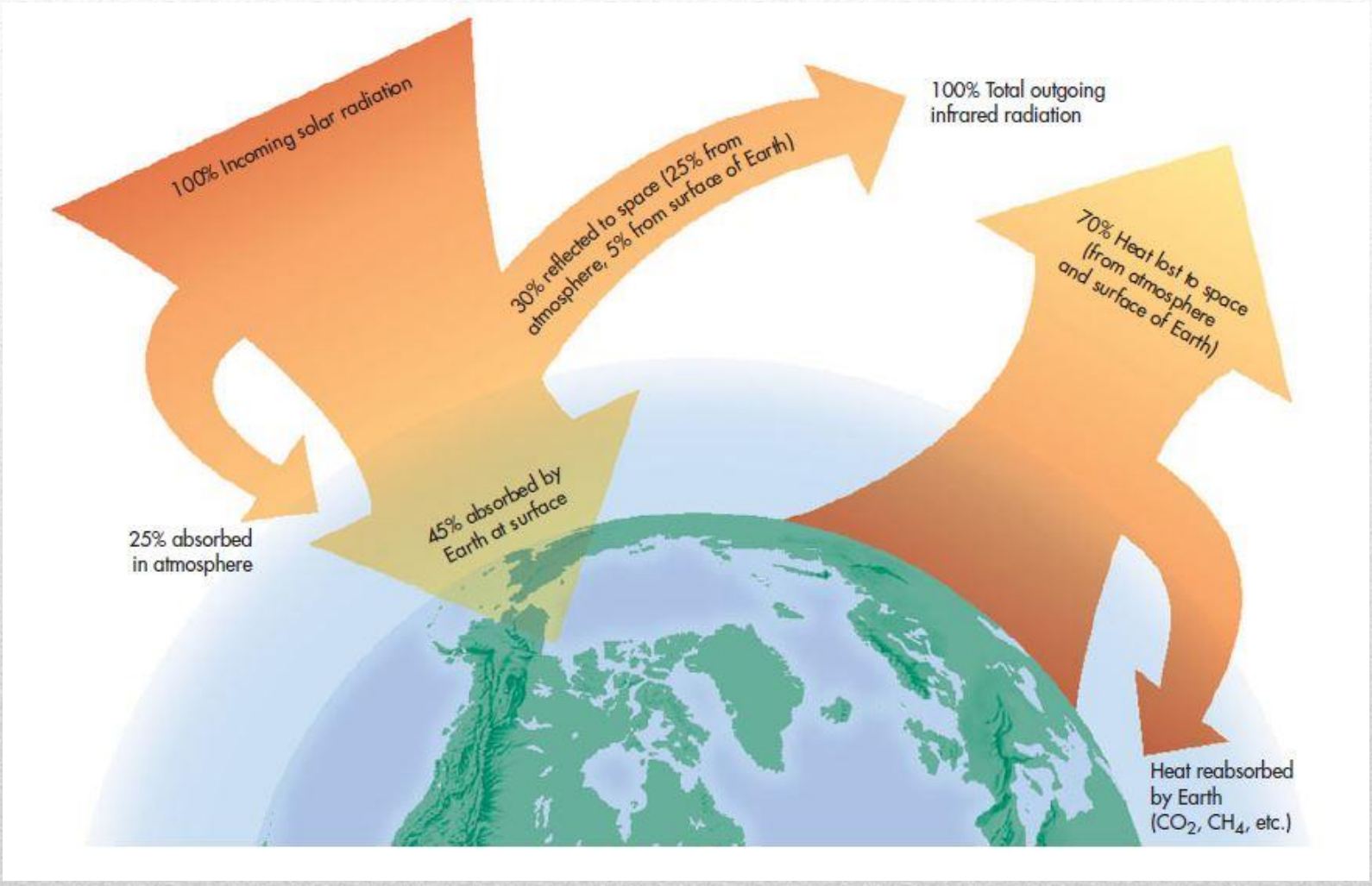
Heat Transfer



Earth's Energy Balance

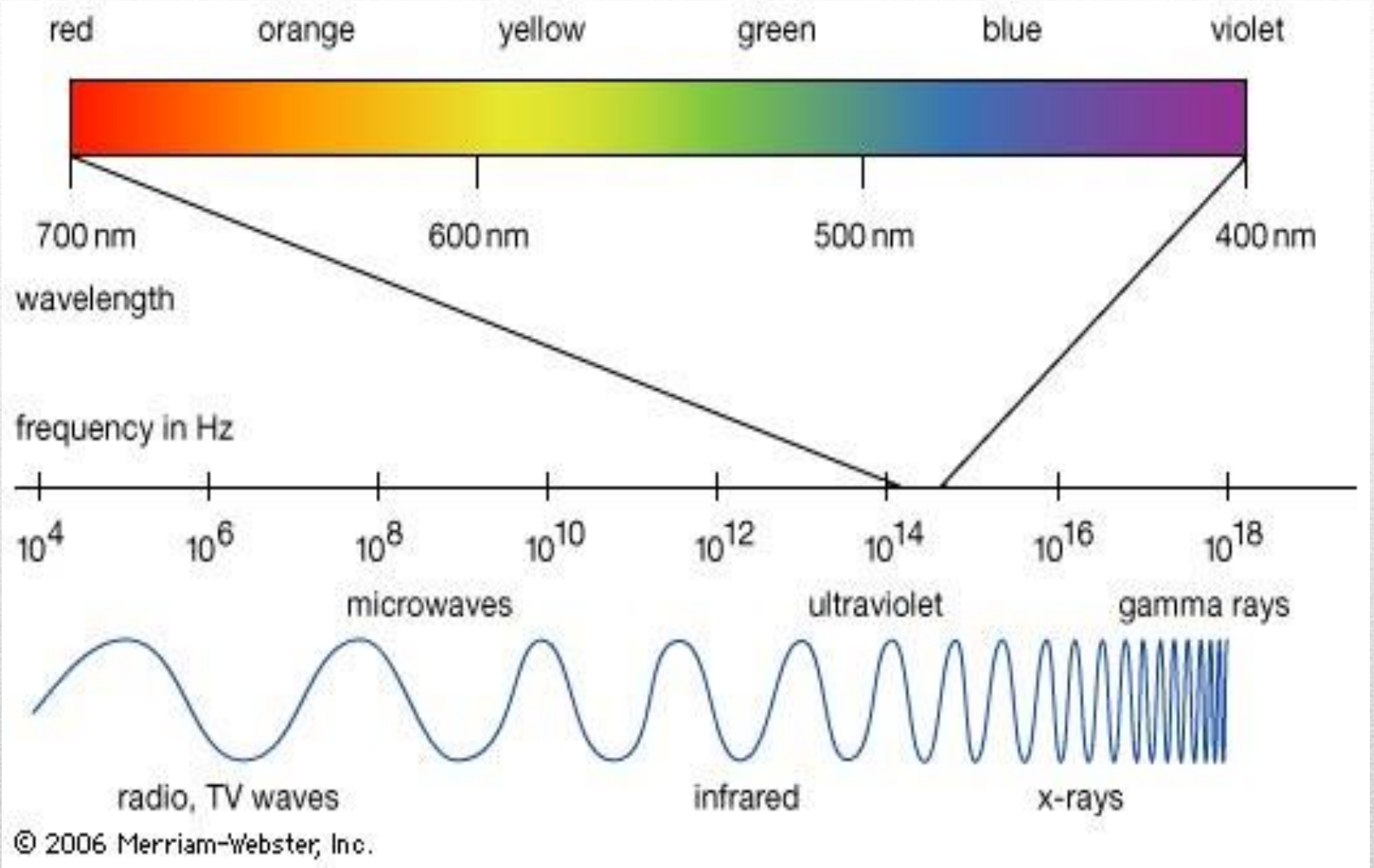
- The **Earth receives Solar Energy everyday**
  - This **energy sustains the Earth**
  - **All the solar energy received by the Earth is radiated back into space**
  - In the **shift from incoming to out going energy some of the energy changes form**, but it is **neither created nor destroyed**.
- This **Solar Energy** drives the
  - Hydrologic Cycle
  - Ocean Waves and Currents
  - Global Atmospheric Circulation
- **Although the Earth's energy balance contains several important components, nearly all of the energy available at the Earth's surface comes from the sun.**

Earth's Energy Balance



Electromagnetic Energy

- Much of the energy emitted from the sun is **electromagnetic energy**
  - This **energy** is a type of **radiation which travels from the sun** to the **earth at the speed of light**
  - This energy is described as a **wave**
  - Distance between the tops of **two successive waves** is called the **wavelength**
  - The various **types of electromagnetic radiation** are **distinguished by their wavelengths**
  - **The is called the electromagnetic spectrum**
    - The ***longer wavelengths*** **include radio waves and microwaves**
    - The ***shorter wavelengths*** **include X-rays and gamma rays**
    - ***Visible wavelengths*** **are a small fraction of the spectrum**


red
orange
yellow
green
blue
violet
700 nm
600 nm
500 nm
400 nm
wavelength
frequency in Hz
10^4
10^6
10^8
10^{10}
10^{12}
10^{14}
10^{16}
10^{18}
microwaves
ultraviolet
gamma rays
radio, TV waves
infrared
x-rays
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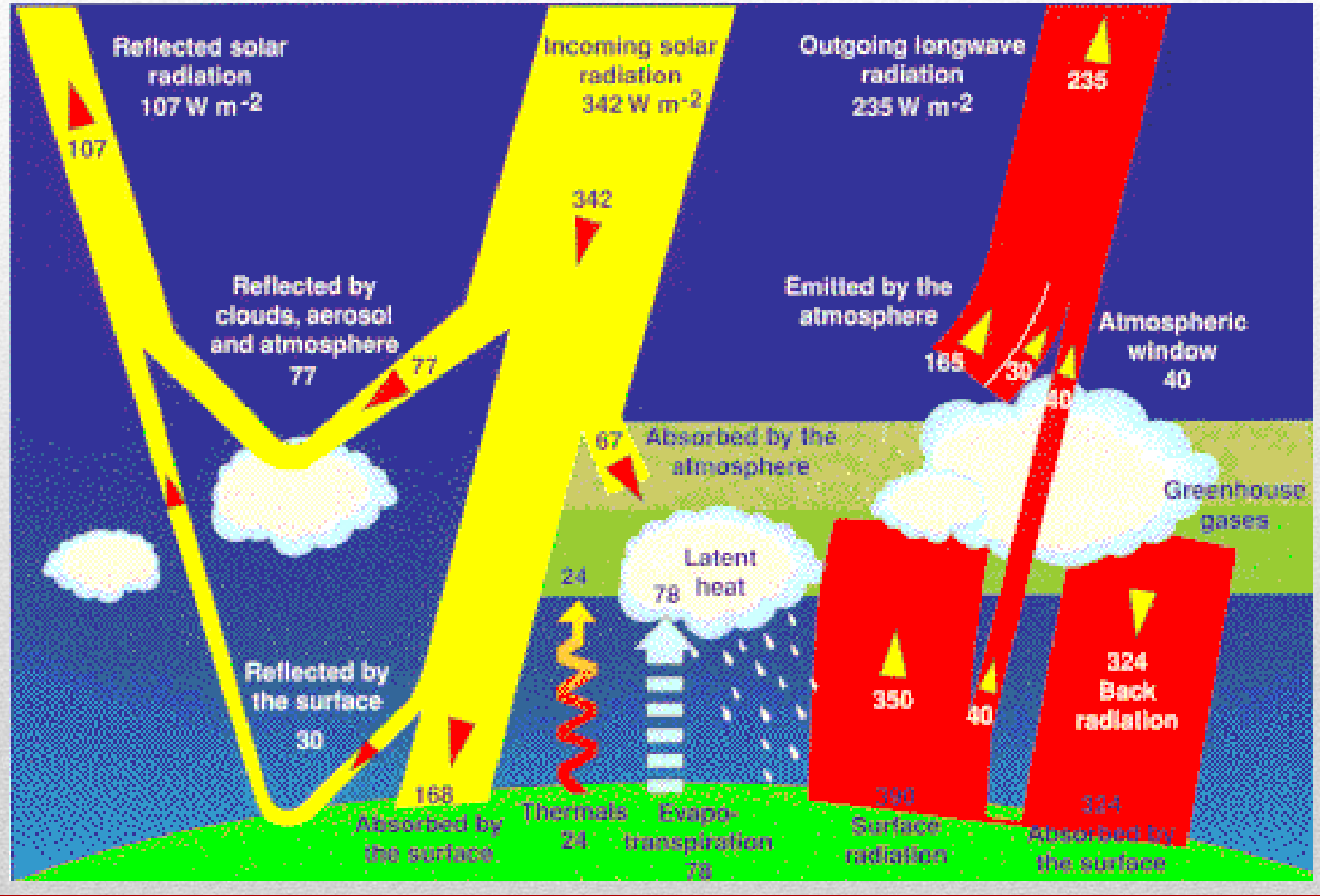
Energy Behavior

- **Once the Solar Energy reaches the Earth it is *redirected, transmitted, or absorbed* by the atmosphere, ocean, and land.**
  - **100 units of Solar Radiation hits the atmosphere.**
    - Some is *absorbed*
    - Some is *reflected*
    - Some is *radiated*
  - **Total units *radiated out are100 units***
- **Albedo**
  - **The *reflective value of an object***
    - The higher the **Albedo value** the *more radiation the object reflects.*
- The **atmosphere is heated by *Earth radiation*** rather than the sun radiation.

Basic Heating & Cooling Processes in the Atmosphere

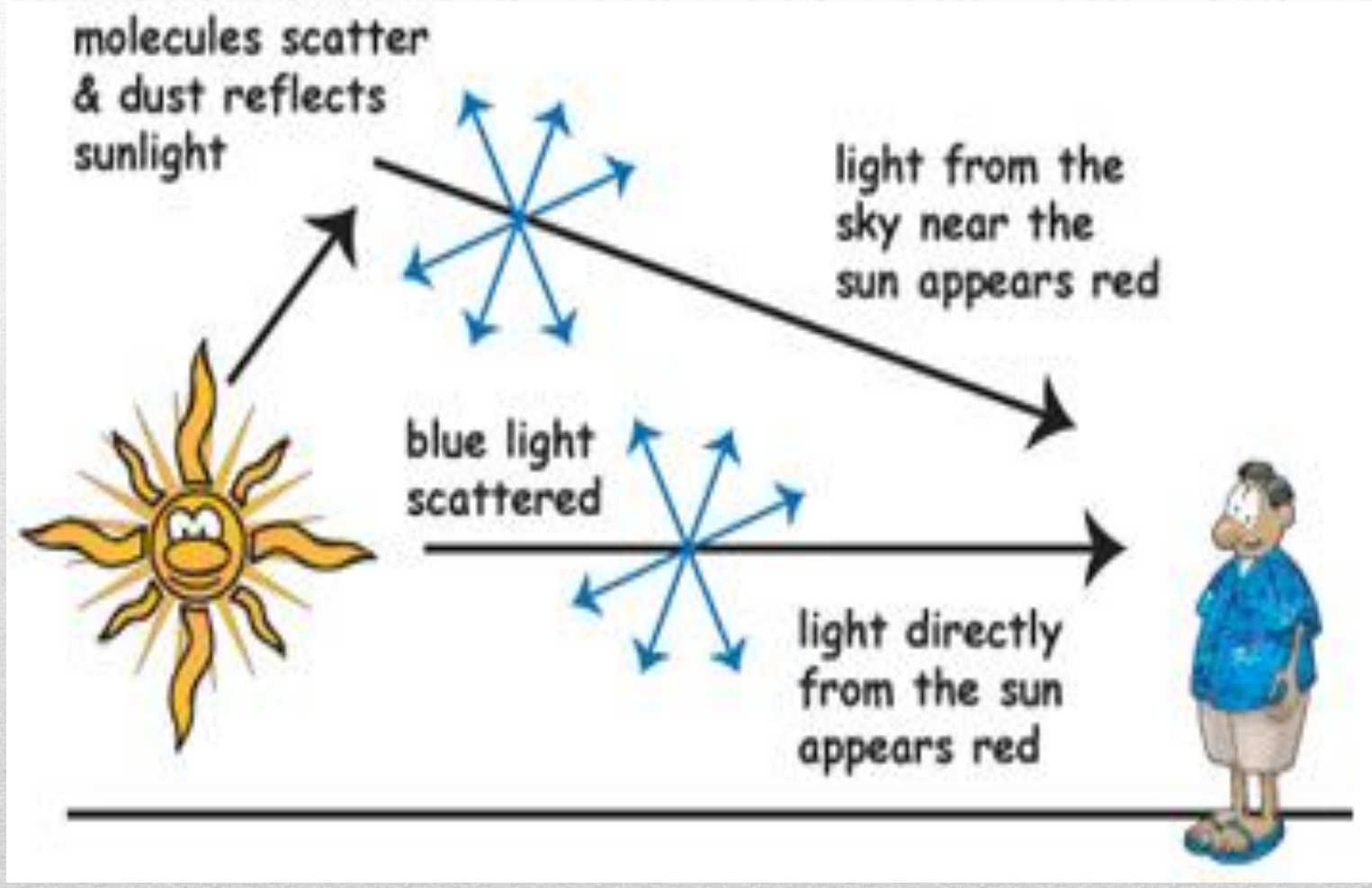
- **Radiation or Emission**
  - The process by which ***electromagnetic energy is emitted from an object***
    - **The hotter the object the *more radiation it emits***
- **Absorption**
  - The **process of *electromagnetic waves by striking an object***
    - **Different objects have *different absorption abilities***
- **Reflection**
  - The **ability of an *object to repel electromagnetic waves without altering either the object or the waves***
- **The *relative amount of energy reflected or absorbed is important in determining the temperature of the air and land***

Earth's Energy Balance



Basic Heating and Cooling Processes in the Atmosphere

- **Scattering**
  - The **act of deflecting or redirecting light waves** with gas molecules and particulate matter in the air.
  - ***Rayleigh Scattering*** – when the **shortest wavelengths are scattered (violet and blue)– causes the "blue sky"**
  - ***Sunset or Sunrise***– **all the blue waves scattered as the energy passes through a longer atmosphere (larger angle) red, orange, and yellow left**


molecules scatter
& dust reflects
sunlight
light from the
sky near the
sun appears red
blue light
scattered
light directly
from the sun
appears red

The Atmosphere

- **Gaseous envelope that surrounds the earth**
  - Made up of **gas molecules, suspended particles of solid and liquid, and falling precipitation**
  - **Causes all the weather we experience**
  - Responsible for **trapping the heat that warms the Earth enough to be habitable**
  - Knowledge of the **structure and dynamics of the atmosphere is critical to understanding severe weather, as well as the mechanism and causes of global warming**

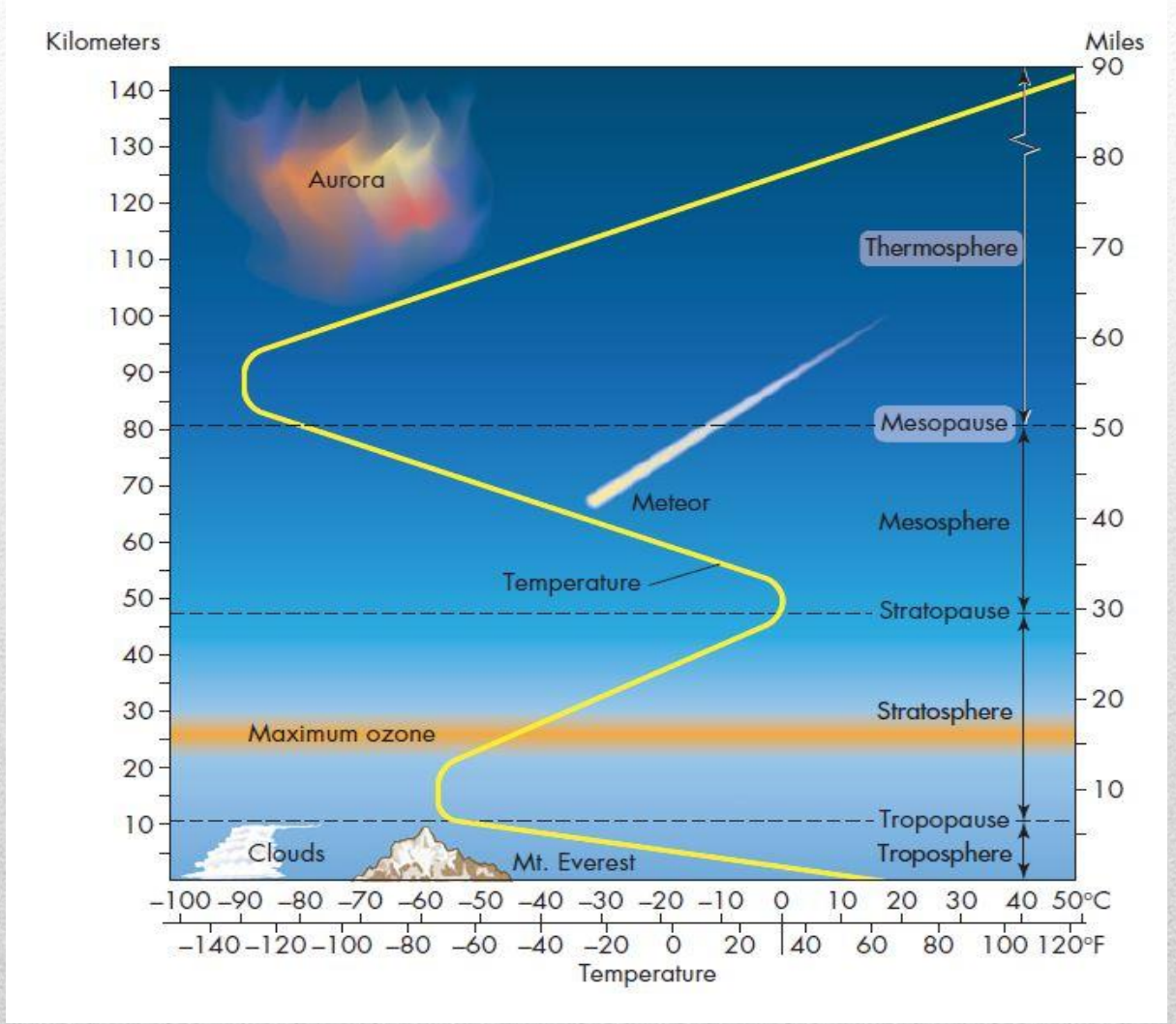
Composition of the Atmosphere

- The main two gases found in the atmosphere are ***nitrogen*** and ***oxygen***
- ***Carbon dioxide*** is next gas found in a small amount in the atmosphere
- ***Relative humidity*** **is one of the types of moisture found in the atmosphere**
  - This is the **most familiar** of moisture measurements
  - This ratio compares the ***actual amount of water vapor in the air to the water vapor capacity of the air at a given temperature***
    - **Capacity** is the **maximum amount of water vapor that can be in the air at a given time**
    - As the ***temperature increases***, **relative humidity decreases**
    - As the ***temperature decreases***, **relative humidity increases**

Structure of the Atmosphere

- ***Thermal layers*** of the atmosphere
  - ***Troposphere and Tropopause*** -- **COLD**
    - **Lowest level**, closest to sea level
    - **11 miles at equator to 8 miles at poles**
    - **Varies with the passages of warm and cold air**
  - ***Stratosphere and Stratopause*--WARM**
    - **Extends from 11 miles above sea level to 30 miles above sea level**
    - **Has the Ozone layer within, causes the warming by stopping Ozone**
  - ***Mesosphere and Mesospause*--COLD**
    - Begins 30 miles and ends 50 miles above sea level
  - ***Thermosphere*--WARM**
    - Begins at 50 miles and gradually extends out
  - ***Exosphere*—NO TEMPERATURE**
    - Outer most portion of the atmosphere
    - Blends with interplanetary space

Structure of the Atmosphere



Weather Process

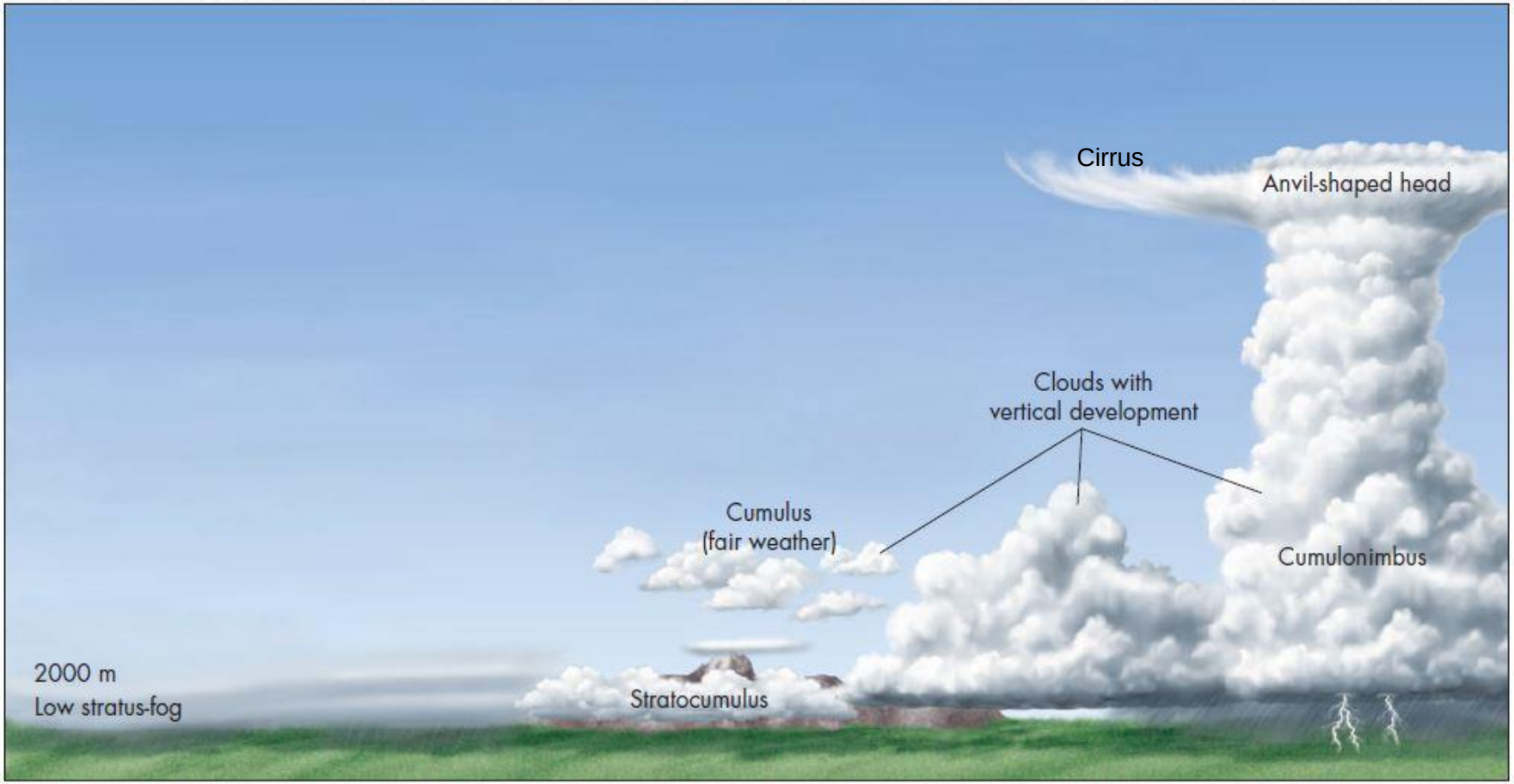
- **Four aspects** of the atmosphere **directly related to severe weather are:**

  - ***Atmospheric pressure and circulation patterns***
  - ***Vertical stability of the atmosphere***
  - ***The Coriolis effect***
  - ***The interaction of different air masses***

Clouds

- **Clouds associated with severe weather**
- Consist of small **water droplets**
- Classified on the basis of **altitude** (low, middle, and high) and **form**
  - **Cirriform** – high thin and wispy and composed if ice crystals – often **proceeds a storm**
  - **Stratiform** – appear as a grayish sheets that cover most or all of the sky, rarely being broken up into individual cloud unites – can be associated with the **formation of fog**
  - **Cumuliform** – massive and rounded, usually with a flat base and limited horizontal extent but often billowing upward to great heights – associated with **severe thunderstorms and tornadoes**

Clouds


Cirrus
Anvil-shaped head
Clouds with
vertical development
Cumulus
(fair weather)
Cumulonimbus
2000 m
Low stratus-fog
Stratocumulus

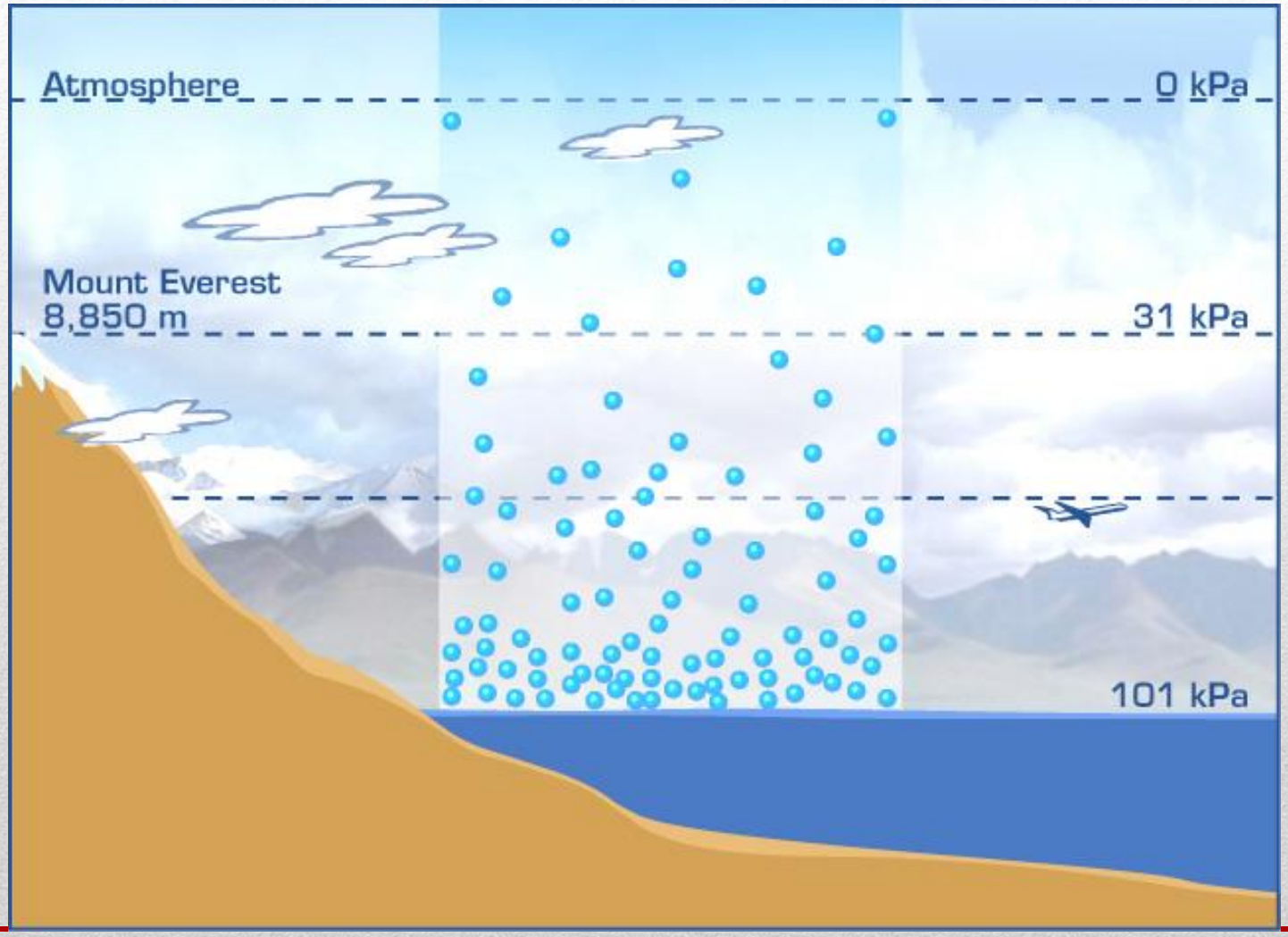
Atmospheric Pressure

- **Atmospheric Pressure is the force exerted by the gas molecules on some area of the Earth's surface or on any body.**
- **This pressure is exerted on every solid or liquid surface it touches**
- **It is Omni-directional, exerted equally in all directions.**
- **Atmospheric pressures are simply the "weight" of a column air above a given point.**
- The ***taller the column of air the greater the pressure***.

Atmospheric Pressure

- Air pressure can be on the **surface of the earth or on a plane in the air**
  - So at ***sea level, the column of air above is longer thus the air pressure is higher, and the air is denser***
  - At a ***high altitude there is a smaller column of air, so the air pressure is lower and the air is less dense***.
  - *Nearly all of the weight of the atmosphere and pressure is in the* ***lower atmosphere below the elevation of 31 miles***
- **The decrease in air pressure decreases with altitude but not at a constant rate.**

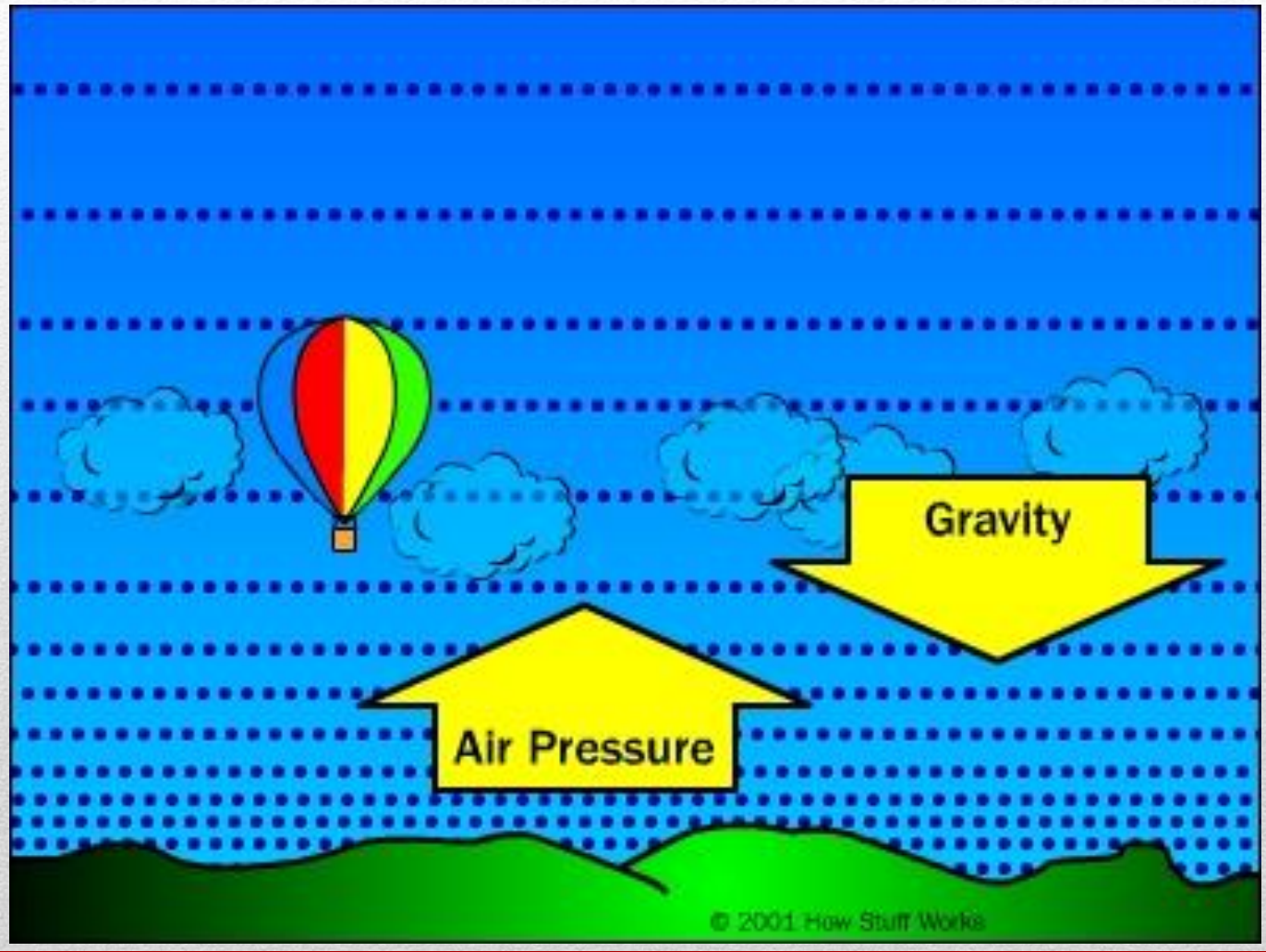
Atmospheric Pressure and Density



Density of Atmospheric Pressure

- **Density and Pressure**
  - **Density is the mass of matter in a unit volume**
    - The *density of a gas is proportional to the pressure* on it and the *pressure the gas exerts is proportional its density*. ***The denser the gas, the greater the pressure it exerts***.
  - ***Atmosphere is held to the Earth by gravity***. So as the *air moves away from the Earth, there is less gravity and less density, thus less pressur*e.
    - ***Higher altitude, less density, less pressure***
    - ***Lower altitude, higher density, higher pressure***

Factors Influencing Atmospheric Pressure



Factors Influencing Atmospheric Pressure

- **Changes in *air temperature* and *air movement*** are responsible for most of the horizontal variation in atmospheric pressure.
  - **Temperature change influences pressure**:
    - ***Cold air is denser than warm air and exerts a higher pressure on the underlying surface***
      - ***The density of cold air is higher because its gas molecules have lower kinetic energy and stay more closely packed together (They're cold)***
  - When ***air pressure and temperature are related, air pressure varies geographically***
  - This has a ***strong effect on the weather and global atmospheric circulation patterns***

Atmospheric Circulation Patterns

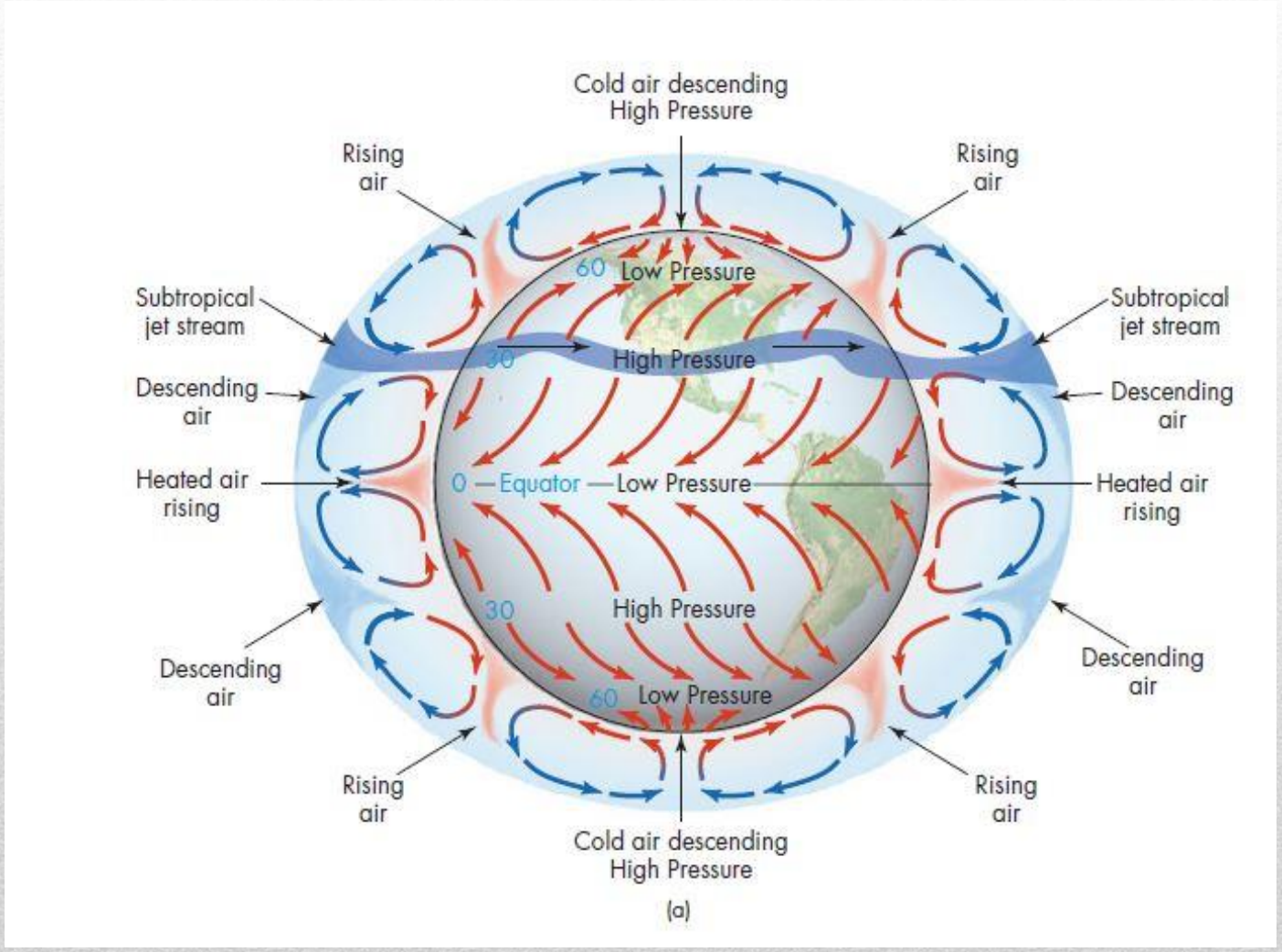
- ***Solar heating and evaporation of seawater at low latitudes create warm masses with high relative humidity***
  - This creates **low-pressure zones** at equatorial latitudes the convect (move) upward in the atmosphere
  - These **zones cool as they rise causing an increase in relative humidity and condensation to form clouds**
  - This creates **abundant precipitation characteristics in the tropics**

- Having ***dropped the rain, the dry, cold and dense air spreads out and sinks at 30 degrees north and south***
  - **Subtropical middle latitude deserts** are the results of these descending air masses
  - These include the Sahara, Arabian, and Mojave deserts

Atmospheric Circulation Patterns

- ***Similar vertical circulation cells are observed at the middle latitudes***
  - This creates **low-pressure zones** at the middle latitudes, **30 to 60 degrees north or south**
  - These zones cool as **they rise causing an increase in relative humidity and condensation to form clouds.**
  - This creates mid-latitude zones of **air masses giving seasonal precipitation**
- Above **60 degrees north and south, are the polar circulation cells**
  - These **circulation cells create descending highs of cold air with relatively low precipitation**

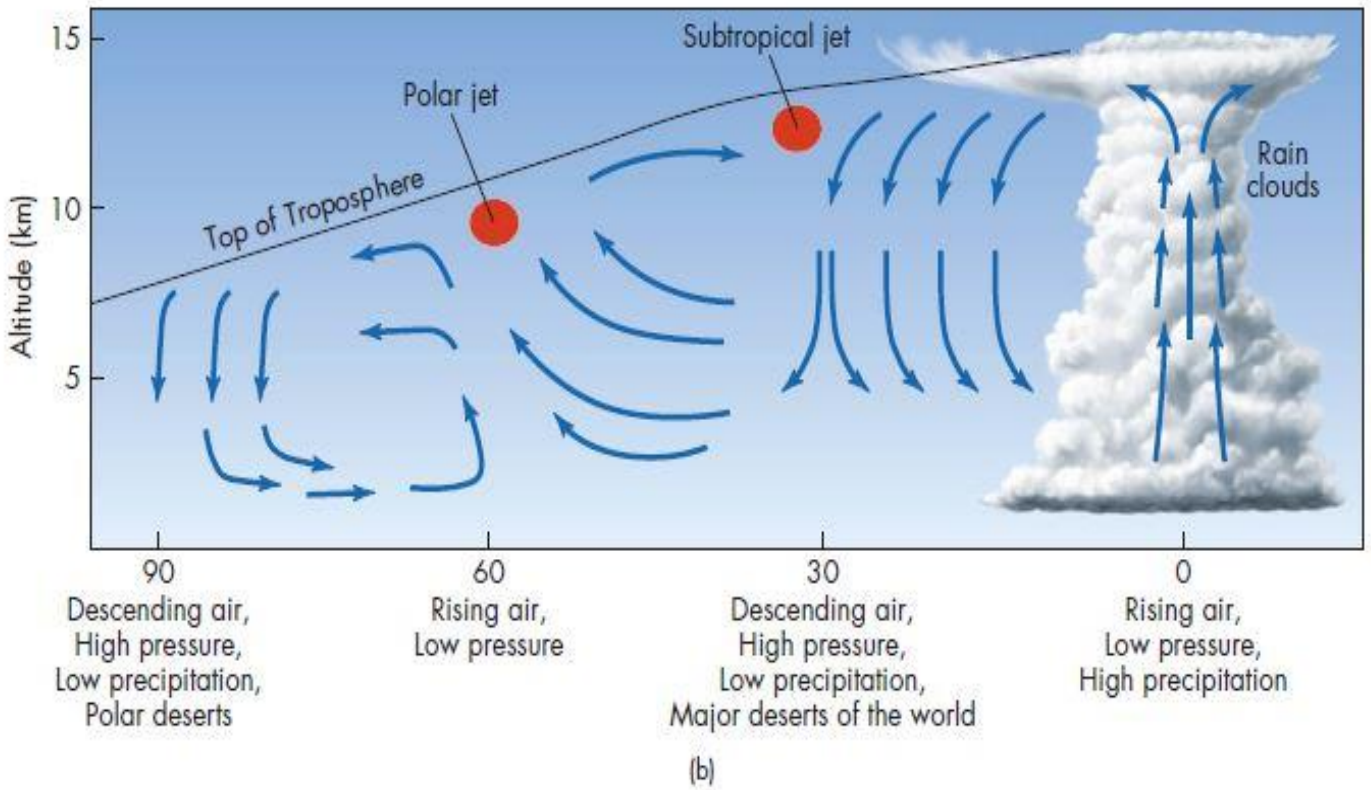
Atmospheric Circulation Patterns



Atmospheric Circulation Patterns

- **Air movement can also cause changes in atmospheric pressure**
- An **overall flow of air into or out of a region is described** as
  - In the **Northern Hemisphere**
    - ***Low pressures (L) – Divergent -- counter clockwise***
    - ***High pressures (H) – Convergent -- clockwise***
  - In the **Southern Hemisphere**
    - ***Low pressures (L) – Divergent -- clockwise***
    - ***High pressures (D) – Convergent -- counter clockwise***
- **Wind Speed – indicates the intensity of the pressure**
  - If the ***gradient is steep, the wind speed is fast***
  - If the ***gradient is gentle the wind speed is slow***
- ***After looking at all these different patterns, it is easy to see that atmospheric pressure is a major driving force for wind and weather***

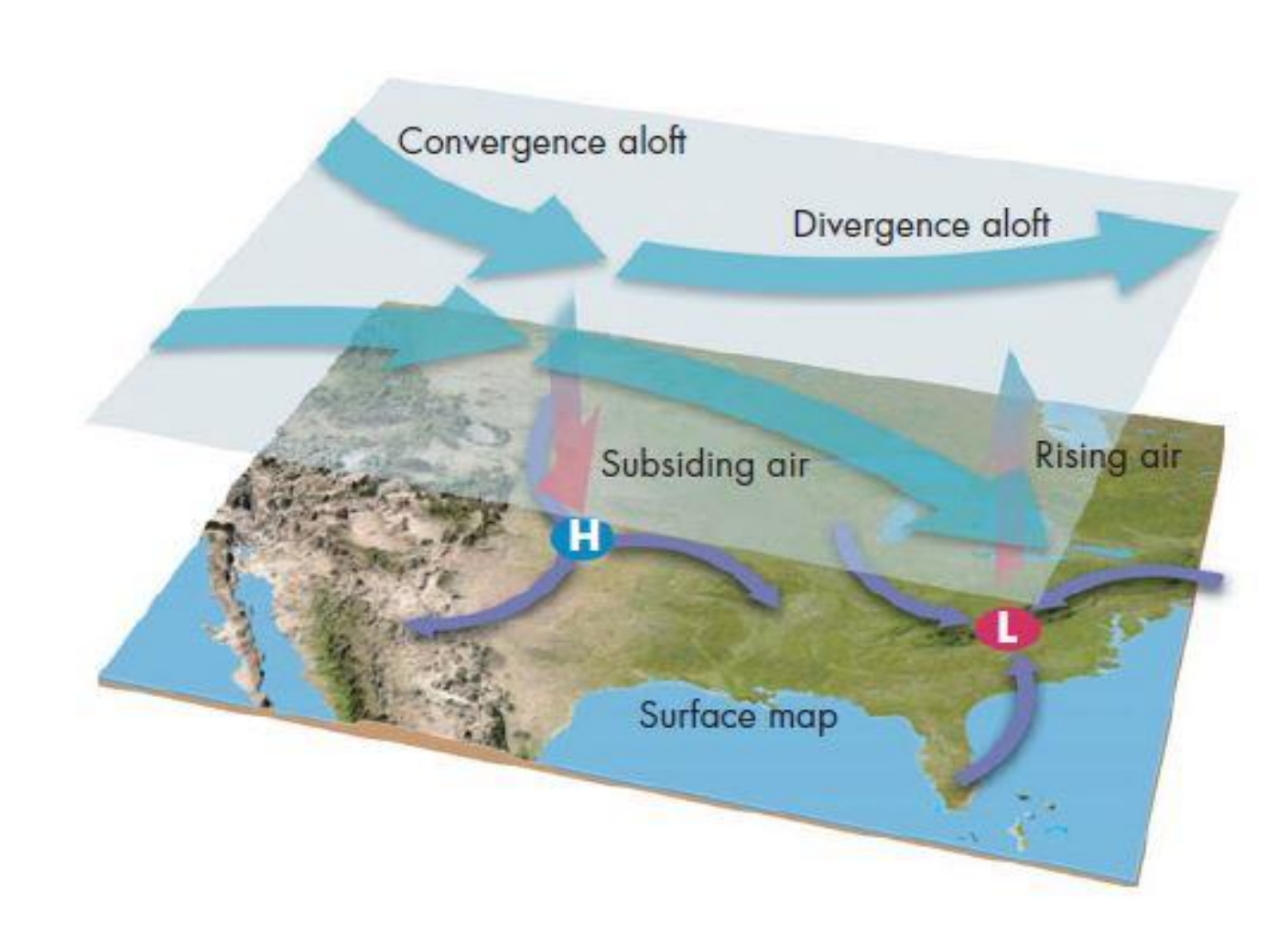
Atmospheric Circulation Patterns



Buoyancy of Air

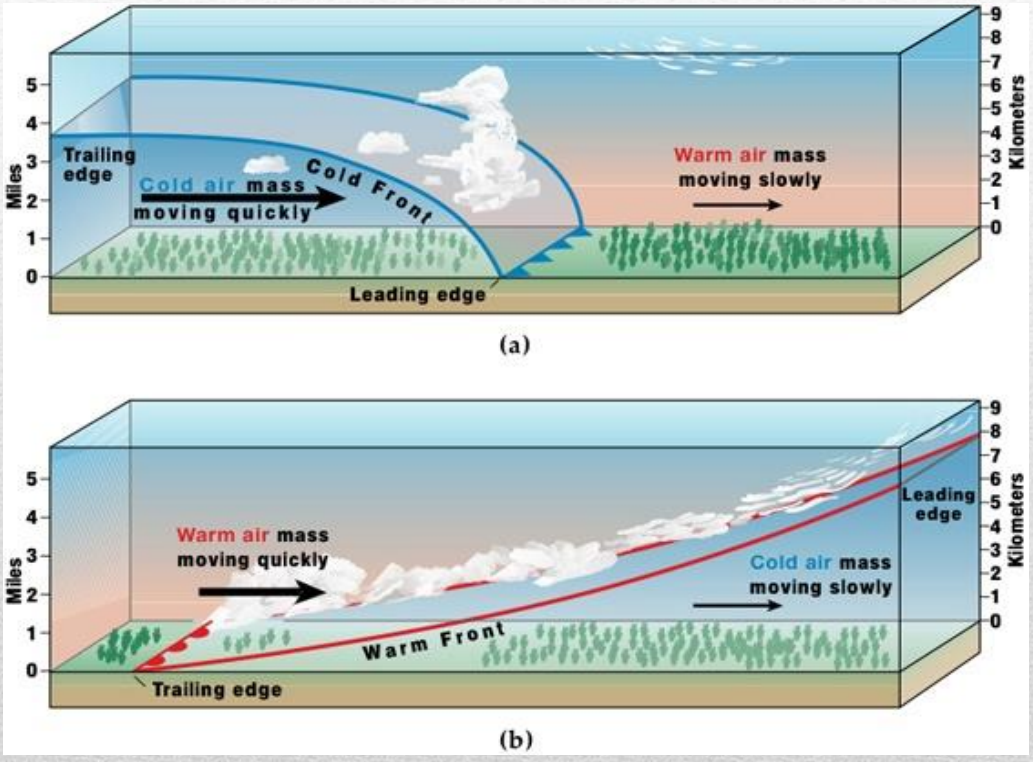
- ***Atmospheric Stability***
  - ***Stable air*** –if a **parcel of air resists upward vertical movement**
    - Could become **unstable if a force is applied, such a topographical feature (mountain slope)**
    - ***Stable air is NON-BUOYANT – High Pressure***
  - ***Unstable air***– if it **either rises without any external force other than the buoyant force or continues to rise after such an external force has ceased to function.**
    - ***Unstable air is BUOYANT – Low Pressure***
    - **Unstable air continues to rise until it reaches temperature and density equal to itself, this is called the equilibrium level.**
    - ***Unstable air is associated with severe weather, such as thunderstorms and tornadoes***

Buoyancy of Air



Fronts

- ***Boundary between a two unlike air masses***
- ***Not two dimensional boundary at the surface, but a three dimensional zone of discontinuity***
- ***Regardless of which air mass is advancing on the other, the warmer air will always be lifted by the colder air mass***
  - **Warm, Cold, Stationary, and Occluded fronts**



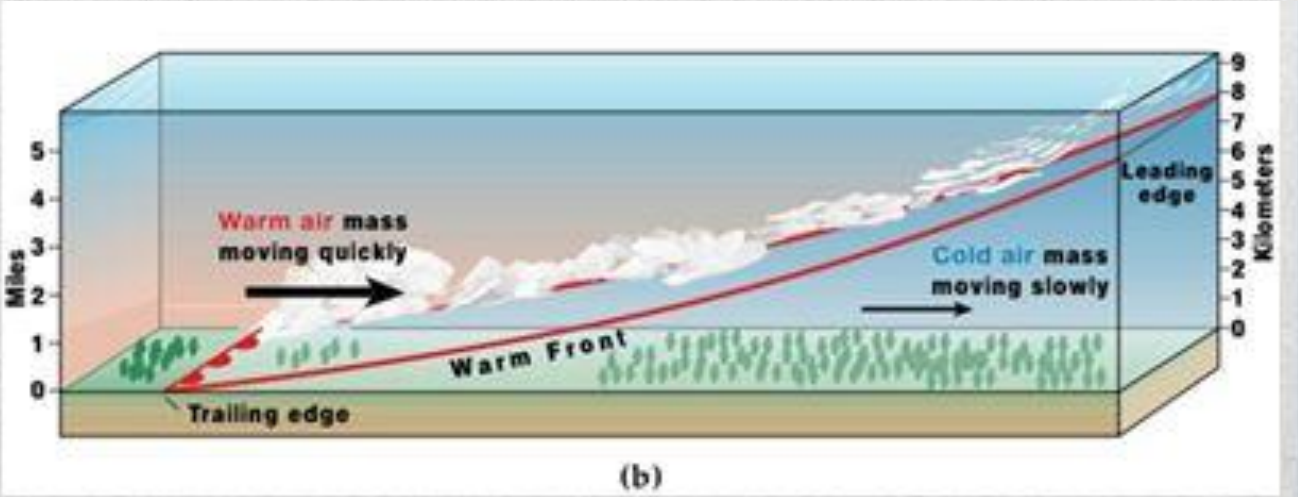
Fronts

- Regardless of which ***air mass is advancing on the other, warmer air will always be lifted by the cold air mass***

- Because of the different temperature, the air masses will have different:
  - ***Humidity levels***
  - ***Wind patterns***
  - ***Stability***

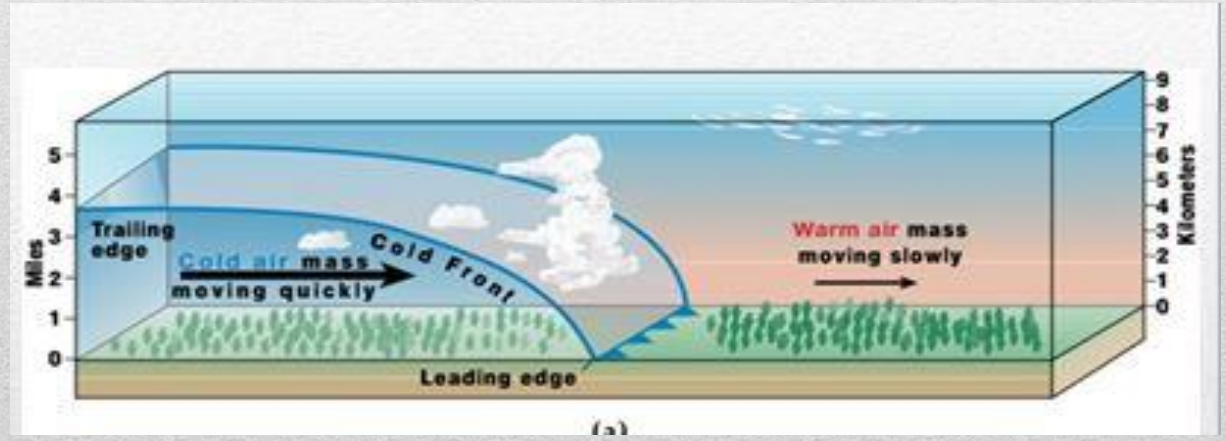
Warm Fronts

- Formed by ***advancing warm air***
- **Slope is *gentle, ascends over cool air*, decreasing in *temperature as the air rises***
- Clouds ***form slowly with not much turbulence*** (**High cirrus clouds**, moving towards a **altocumulus or altostratus**
- ***Broad precipitation, protracted and gentle***



Cold Fronts

- Forms by ***advancing cold air***
- Is a ***steeper front than a warm front*** *with a "****protruding nose****"*
- ***Moves faster than a warm front***
- ***Rapid lifting, unstable air, blustering and violent weather***
- ***Vertically developing clouds***
- If ***unstable air, precipitation can be showery or violent***
- ***Precipitation along the leading edge and immediately behind the ground-level position of the front.***



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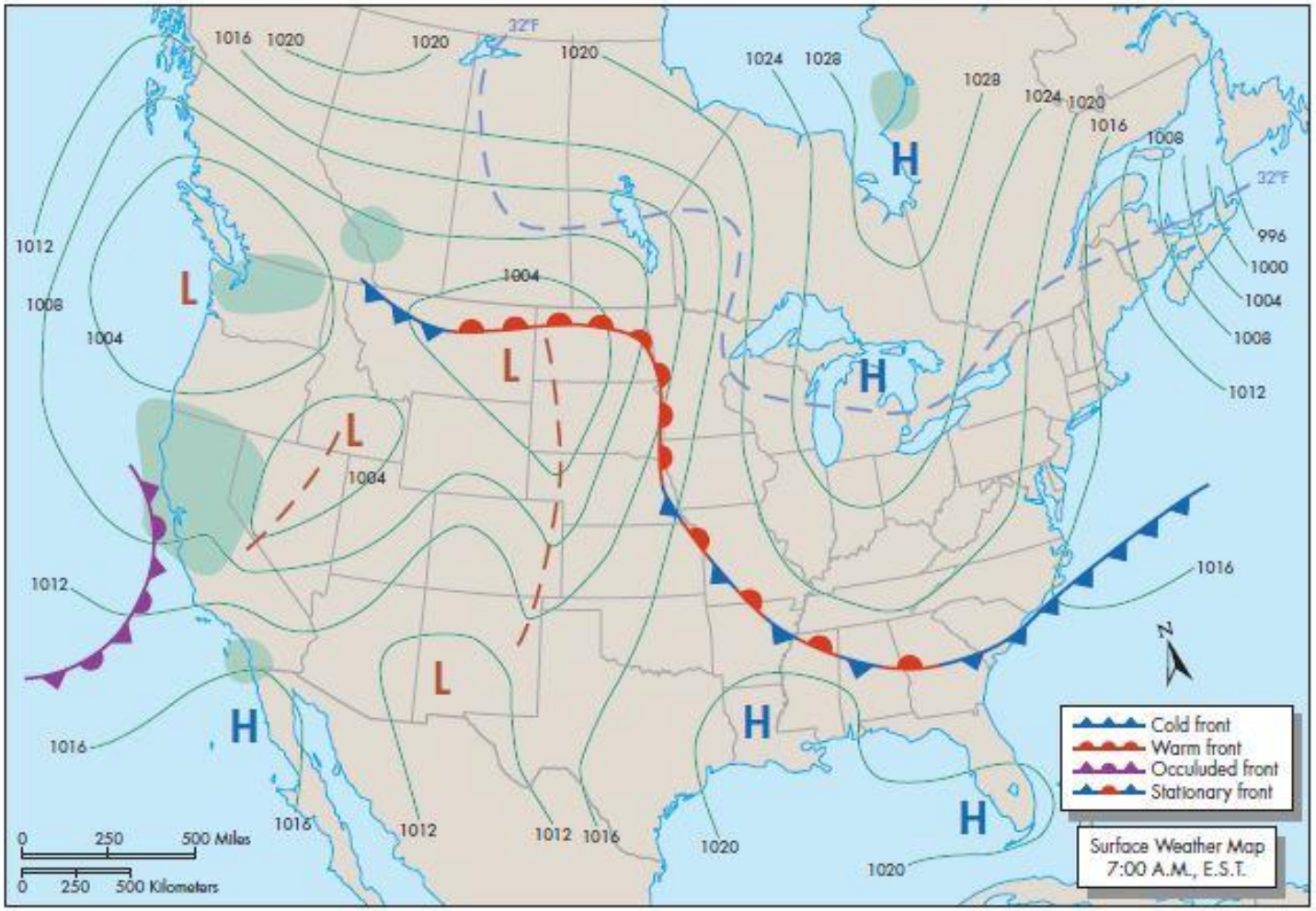
Stationary and Occluded Fronts

- **Stationary Fronts** – Boundary ***between the warm and cold fronts***
  - May stay ***stationary for a few hours to days***
- **Occluded Fronts** – when the ***rapidly moving cooler air overtakes another cooler air mass and warm air is wedge above the frontal boundary***
- ***Each of the four types of Fronts can cause inclement weather***


1016
1020
1020
32°F
1020
1024
1028
1028
1024
1020
1016
1008
32°F
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1000
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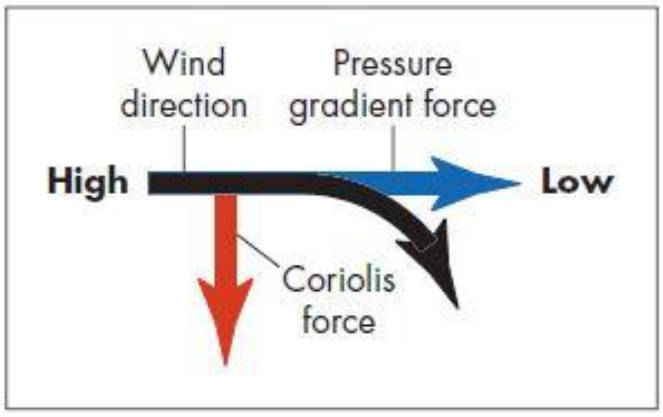
1012
1016
1020
1020
L
L
L
L
H
H
H
H
H
N
Cold front
Warm front
Occluded front
Stationary front
Surface Weather Map
7:00 A.M., E.S.T.
0 250 500 Miles
0 250 500 Kilometers

The Coriolis Effect or Force

- ***Appearance of all things drifting sideways*** as a result of the Earth's rotation.

- **Why?** If a rocket is shot directly at New York, by the time the rocket arrives at New York, the ***Earth has rotated and the rocket seems to have "drifted"***

- ***Applies to any freely moving object.***



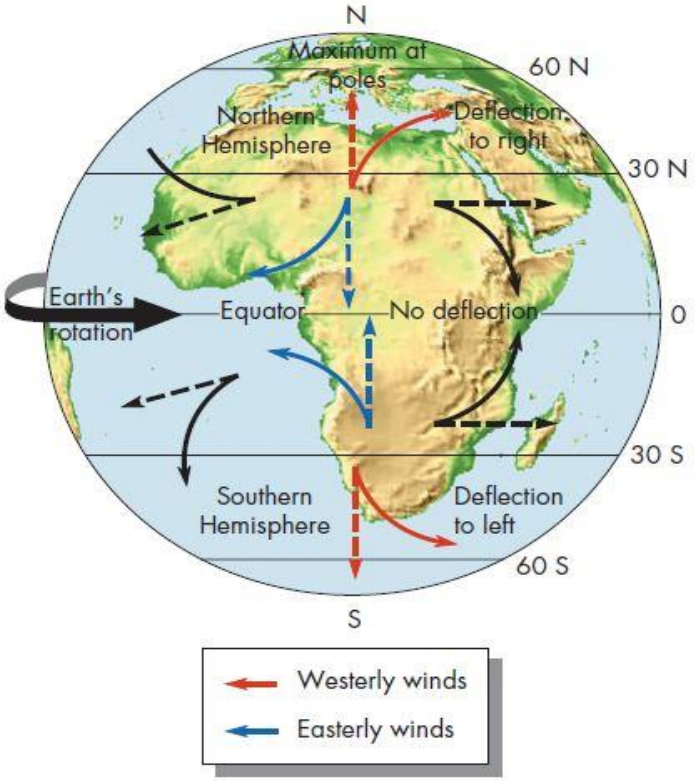
Four Basic Points of the Coriolis Effect

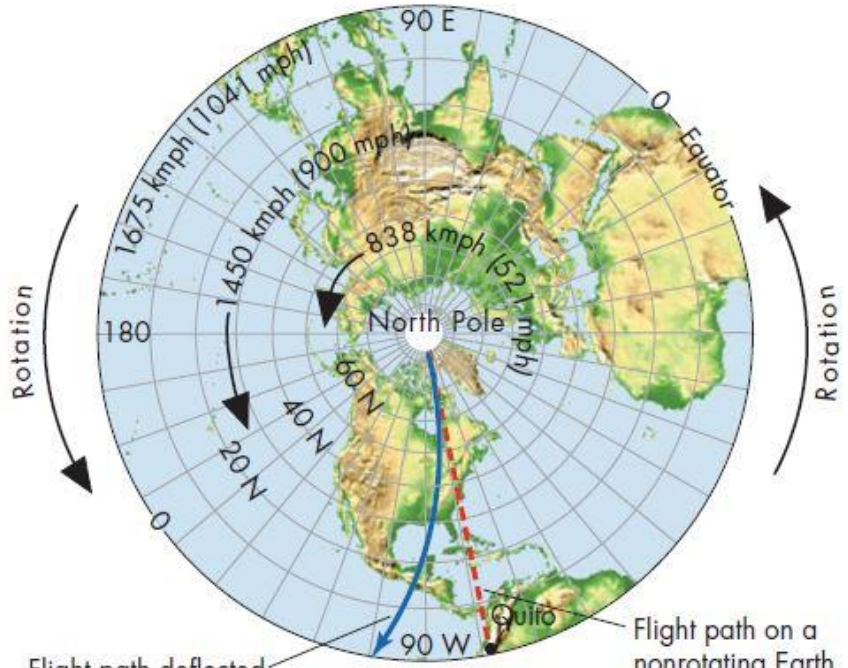
1. 1. ***Regardless of the initial direction of motion***, any freely moving object appears to deflect to the ***right*** in the **Northern Hemisphere** and to the ***left*** in the **Southern Hemisphere**

2. 2. The apparent deflection is ***strongest*** at the **poles** and ***decreases*** **progressively toward the equator** where there is zero

3. 3. The Coriolis effect is ***proportional*** to the ***speed*** of the object, so a ***fast-moving object is deflected more than a slow one***

4. 4. The Coriolis effect ***influences direction of movement only***… it has ***no effect on speed*****.**





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Hazardous Weather

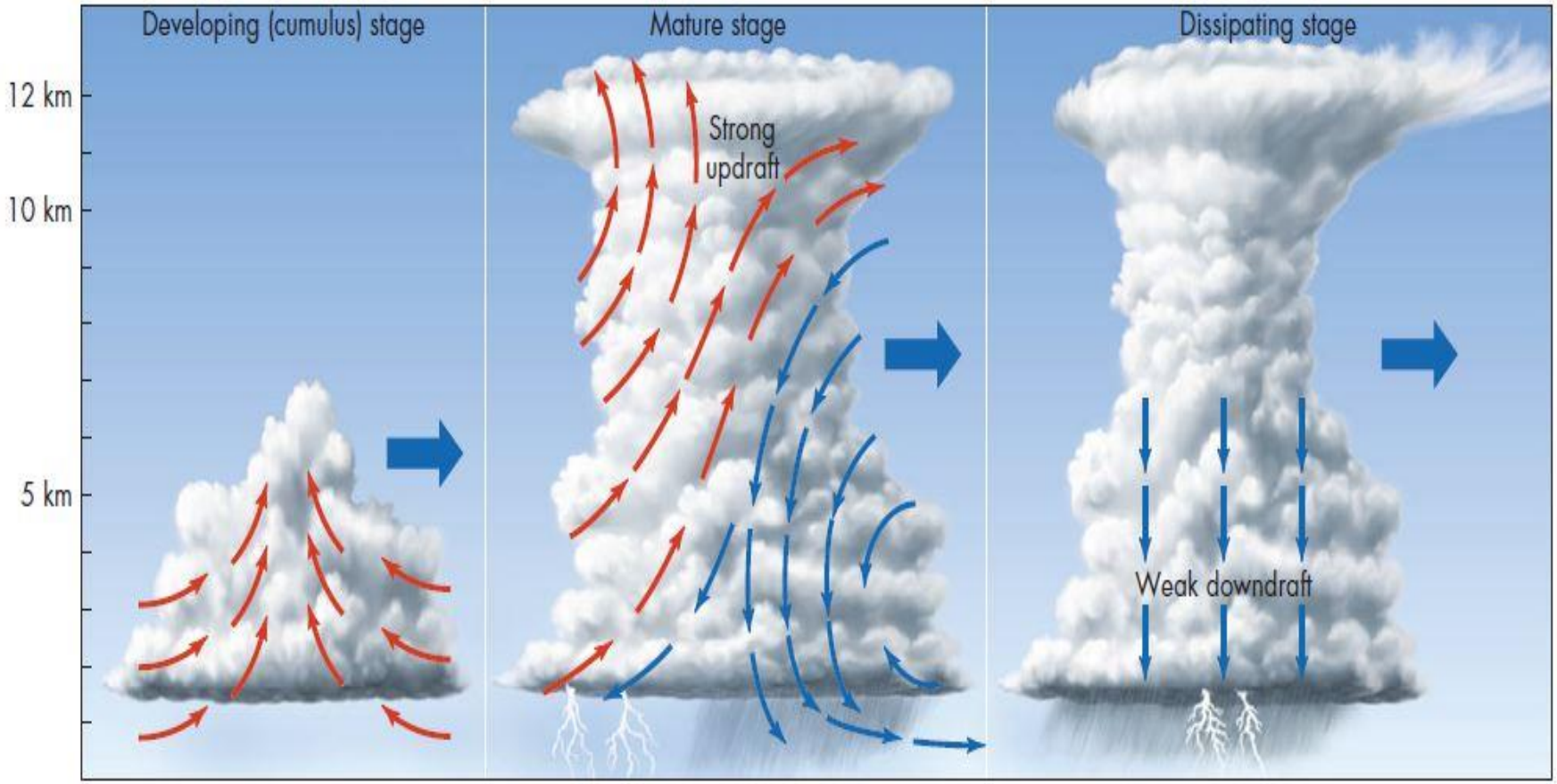
- The ***basic principles of the atmosphere which we have looked at can help us understand associated hazards***
- ***Severe weather*** refers to:
  - **Thunderstorms**
  - **Tornadoes**
  - **Hurricanes**
  - **Blizzards**
  - **Ice storms**
  - **Mountain windstorms**
  - **Heatwaves**
  - **Dust storms**

Thunderstorms

- **Thunderstorms:**
  - ***Three basic atmospheric conditions* are necessary for a thunderstorm to form:**
    - ***Warm humid air must be available in the low atmosphere***
    - ***A steep vertical temperature gradient must exist in the environment***
    - ***An updraft must force moist sir up to colder levels of the atmosphere***

Thunderstorms

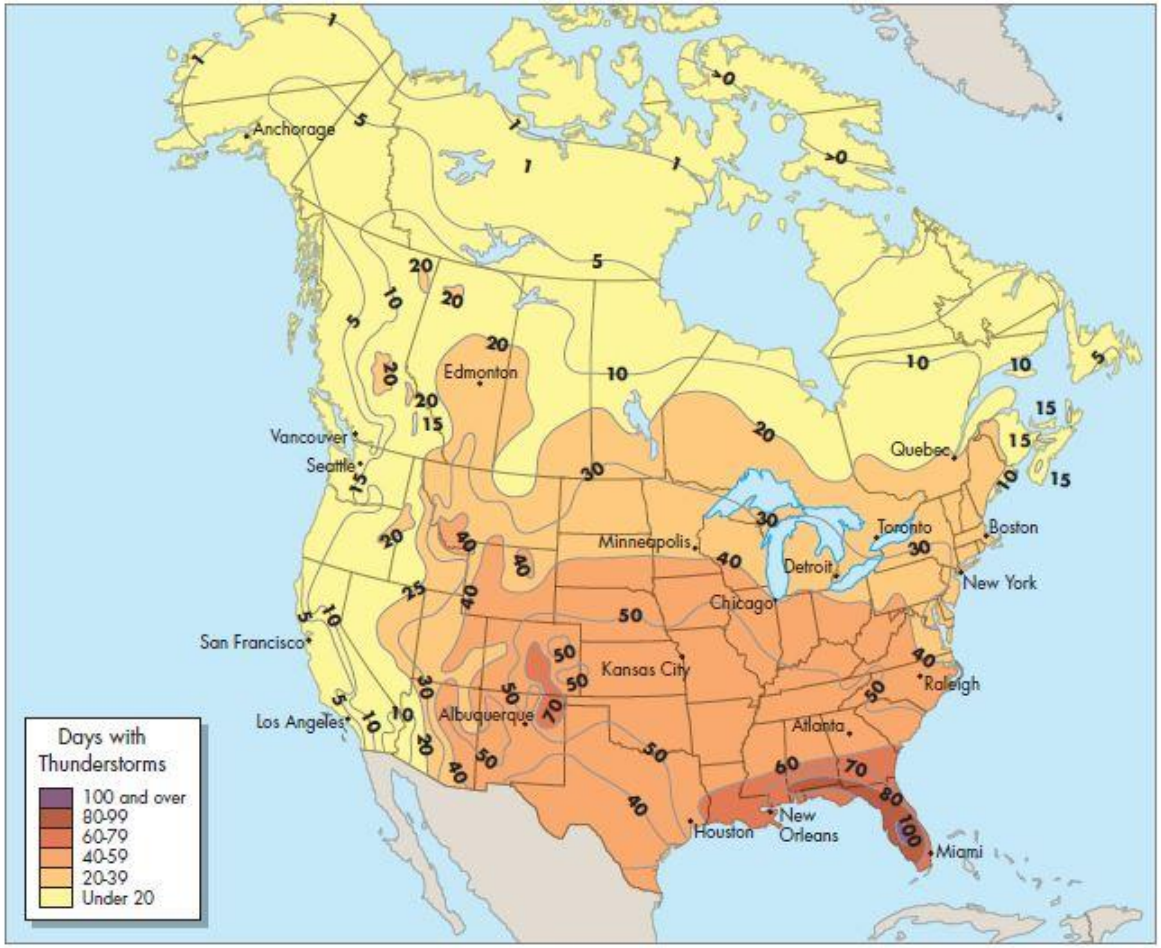
- **Thunderstorms:**
  - **Defined as a *violent convective storm* accompanied by thunder and lightning**
  - ***Found frequently found in conjunction with other kinds of storms***
  - ***Triggered by unstable uplift***
  - **Formation called the *cumulus stage***
  - ***Mature stage* – in which updrafts and downdrafts coexist as the cloud continues to enlarge** – heavy rain accompanied with hail, blustery winds, lighting, and the growth of the anvil top
  - ***Dissipating stage* -- with light rain ending the turbulence.**


Developing (cumulus) stage
Mature stage
Dissipating stage
12 km
10 km
5 km
Strong updraft
Weak downdraft

Localized Severe Thunderstorms

- **Severe Thunderstorms can have**
  - ***Wind exceeds 58 mph***
  - ***Hailstones larger than ¾ of an inch***
  - ***Generates a Tornado***
- **Conditions to create a severe thunderstorm are**
  - ***Changes in wind shear***
  - ***High water-vapor content***
  - ***Updraft of air***
  - ***The existence of a dry air mass above a moist air mass***
  - ***Most important is the Vertical wind shear***
  - ***The most damaging is the supercell storm***
  - ***Hailstones can be a hazard from a thunderstorm***
- ***Hailstones-cause more damage than casualties***

Thunderstorms Locations



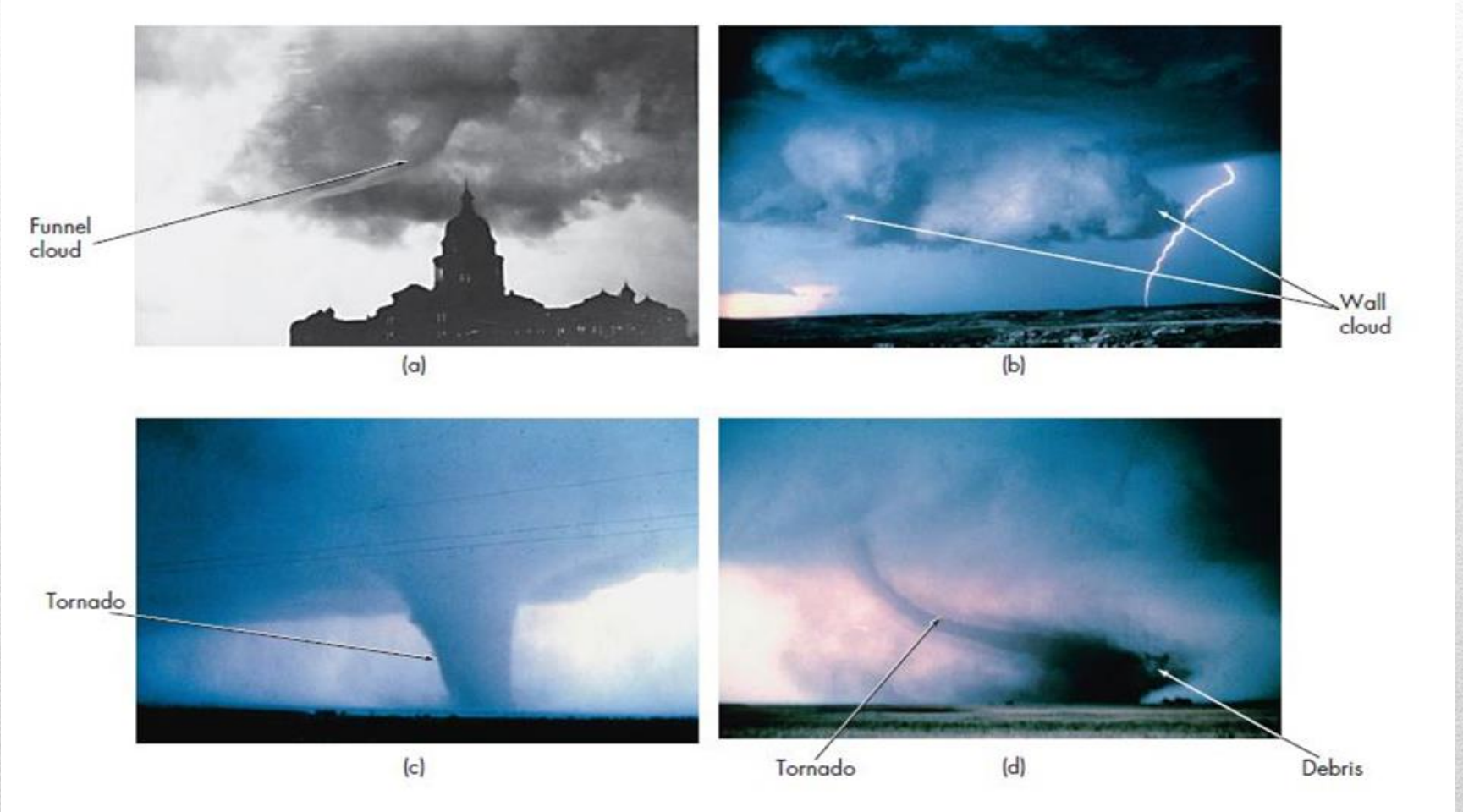
Hail

- **Large thunderstorms can produce hard pieces of ice called *hailstones***
- ***Severe thunderstorms produce large hail which is the most dangerous***
- **Start as a small piece of ice in the center of a thunderstorm**
- ***Travel up and down the cloud in the cold, freezing more and more ice around the center***
- **Eventually *gets so heavy that it falls to the ground***
- ***Hailstorms can cause a great deal of property damage***

Tornadoes

- **Very small and localized**
- **Most destructive of all atmospheric disturbances**
- **Most intense vortex in nature , deep low pressure cell surrounded by a violently whirling cylinder of wind**
- **Less than a quarter of a mile in diameter but most extreme pressure gradients known** (100-millibar difference from the center to the edge)
- **Upswept water vapor condenses into a funnel cloud**

Stages in Tornado Development

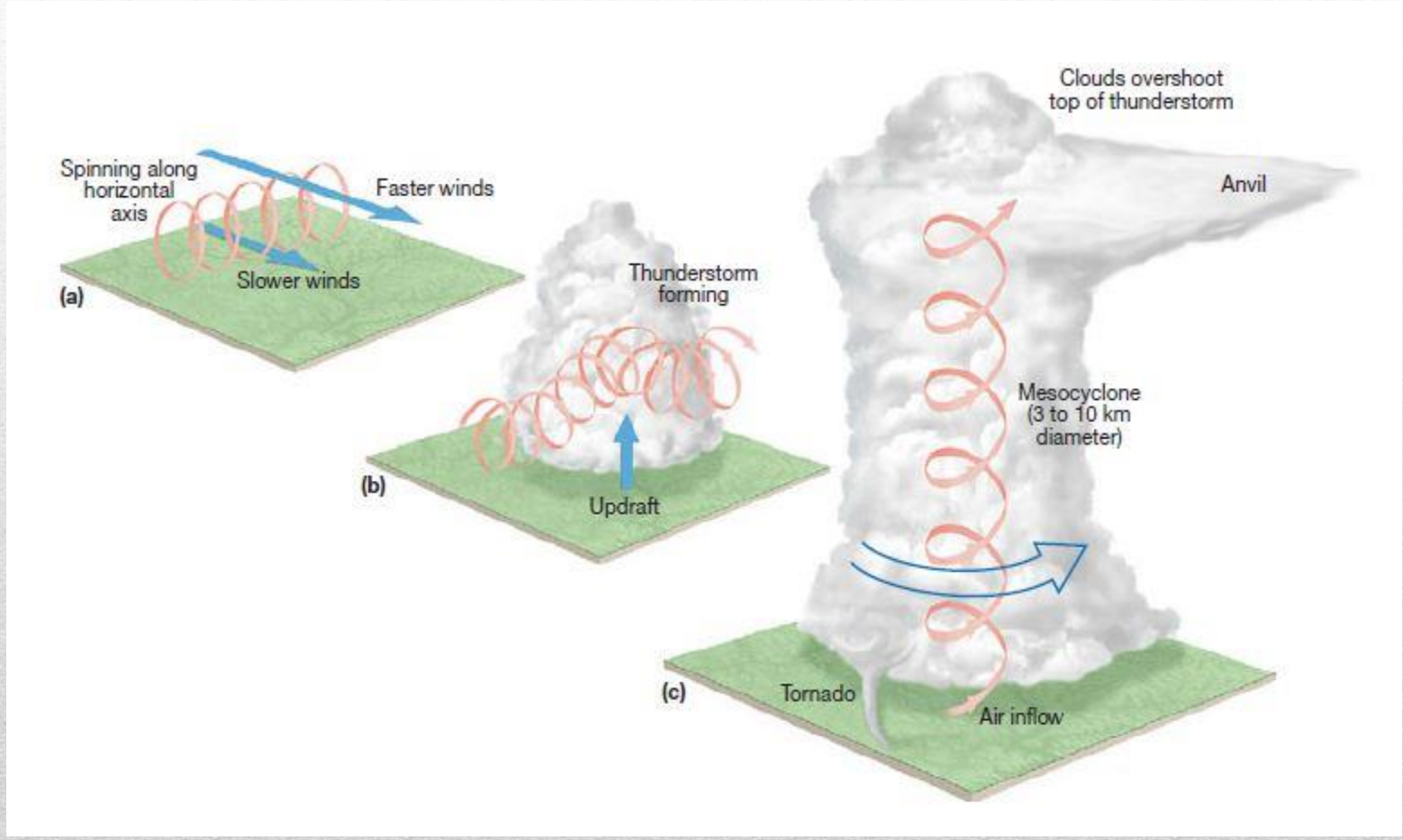


Tornadoes

- **Advances along an irregular track that generally extends from southwest to northeast in the US**
- **Fujita tornado intensity scale (F-scale) for intensity**
- **Formation – develop in the warm moist unstable air associated with a mid latitude cyclone, along the squall line**
- **Develops out of mesocyclone, but only about half of all mesocyclones formed result in a tornado**
- **More than 90 % of tornadoes happen in the US in Tornado Alley**

44cd_Tornadoes_E2.swf

Tornado Formation



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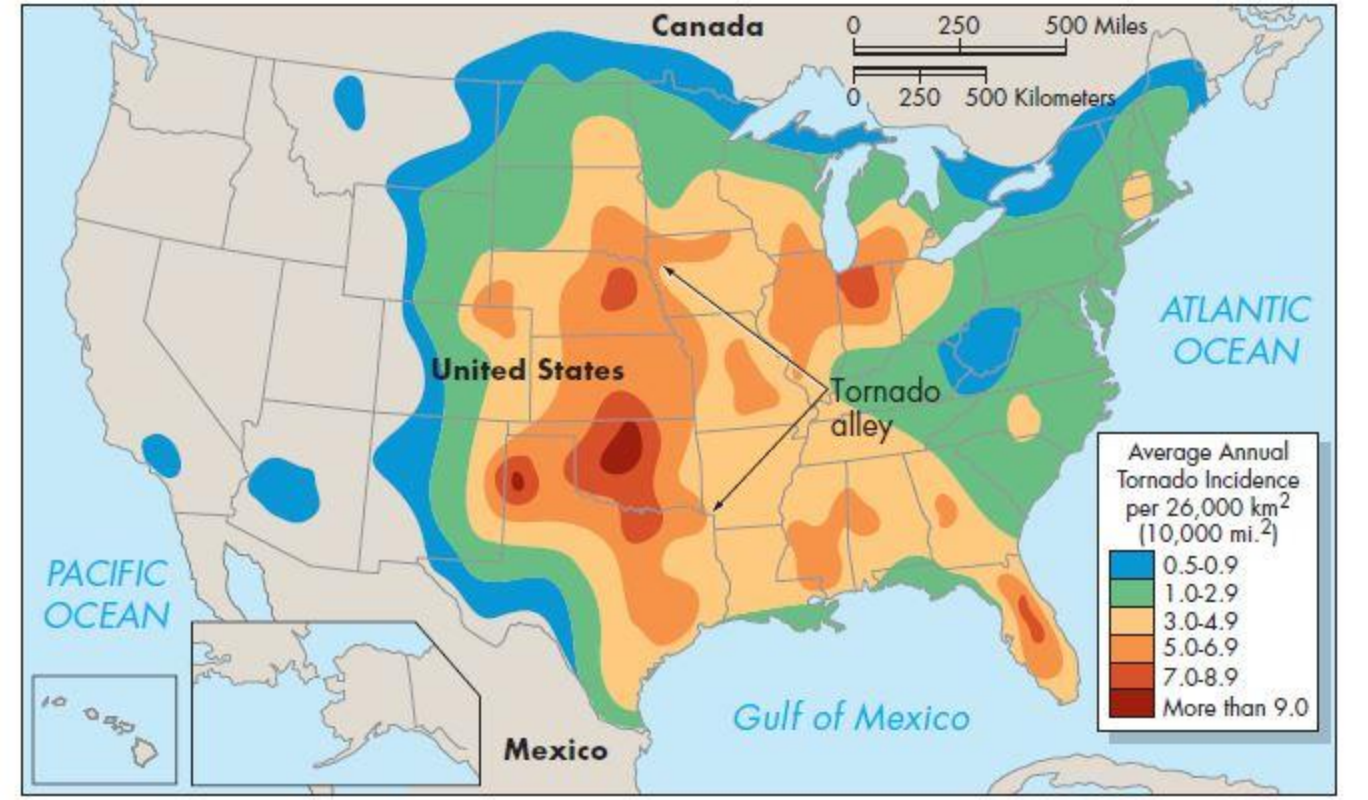
Tornado Alley

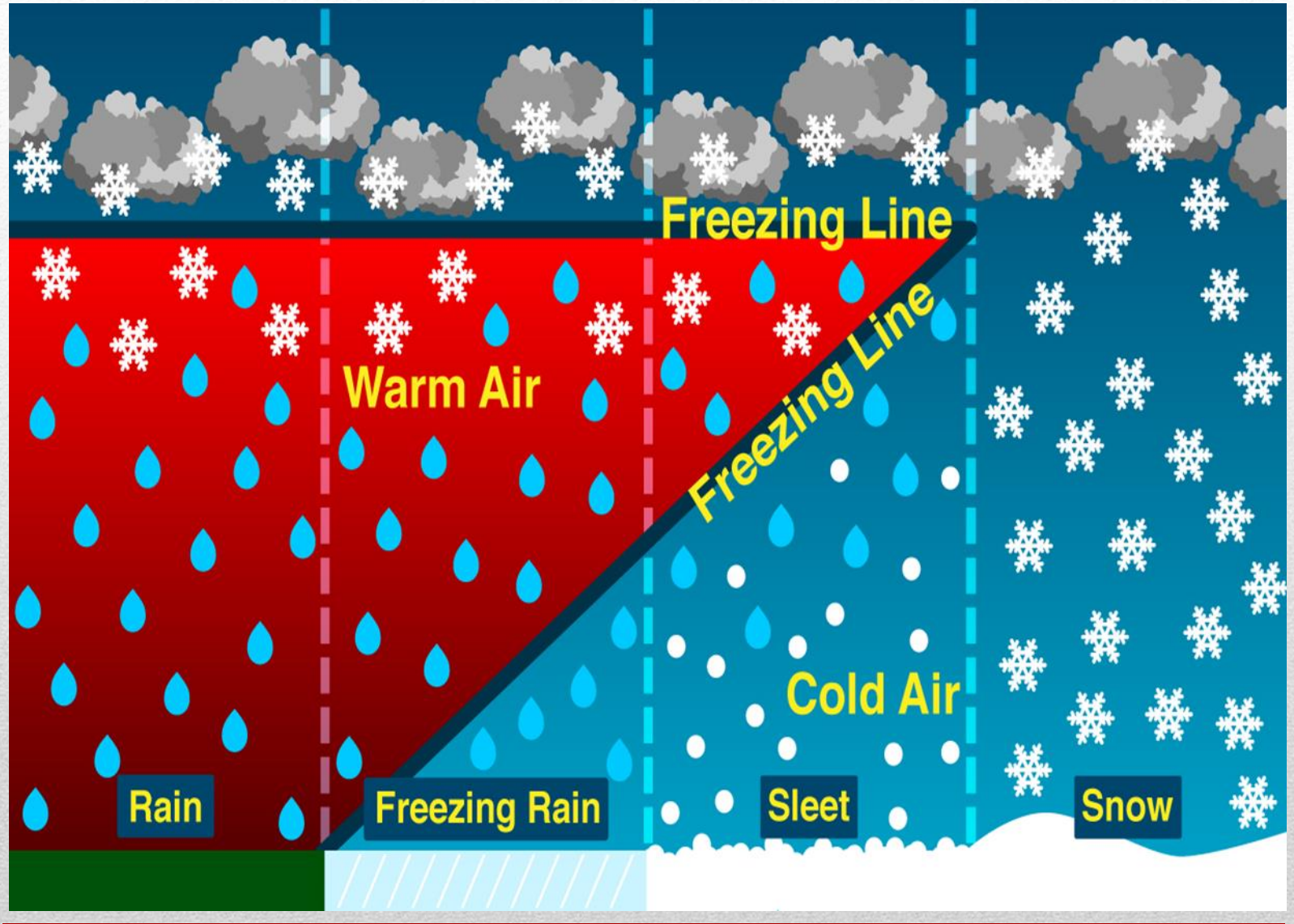


Blizzards and Ice Storms

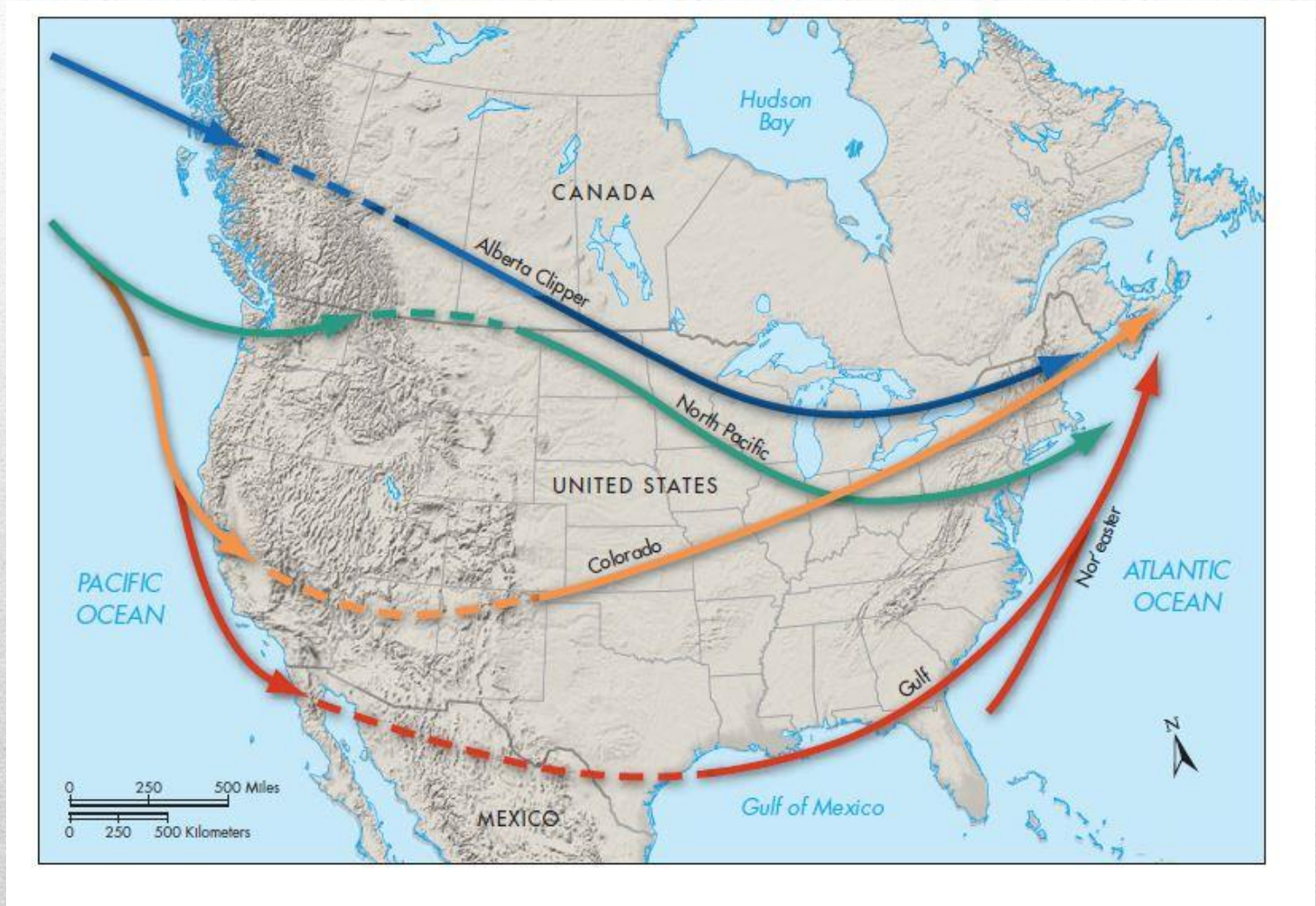
- **Blizzards**- ***Severe winter storms***
  - **Large amounts of falling snow**
  - **High Winds**
  - **Long lasting**
  - **Low visibilities**
  - **Extended periods of time**
  - **Often whiteouts because of the snow**
  - **Cold temperatures**
  - **Found across the country, *extremely hazardous in the midland of the US***
  - **In the east, they can be called *nor'easters***
  - ***Extremely dangerous because of the wind chill***

Blizzards and Ice Storms

- **Ice Storms**
  - **Prolonged periods of *freezing rain***
  - **Develop mostly in the *north side of a stationary or warm front***
  - **Three conditions that cause Ice Storms to happen**
    - ***Ample source of moisture in a warm front***
    - ***Warm air uplifted over shallow layer of cold air***
    - ***Objects on the land surface close to freezing***
  - ***Everything covered with ice***
  - **Often found in the *mid-west or east***


Freezing Line
Freezing Line
Warm Air
Cold Air
Rain
Freezing Rain
Sleet
Snow

Winter Storm Tracks



Fog

- ***A Cloud on the ground* – becomes hazardous when it *obscures visibility or if pollutants are added to form smog***
- **There are *four kinds of fog* that can develop. These are:**
  - ***Radiation fog*** – results when the ground loses heat through radiation usually at night.
  - ***Advection fog*** – develops when warm, moist air moves horizontally over a cold surface, such as snow-covered ground or cold ocean current
  - ***Upslope fog or orographic*** fog -- by adiabatic cooling when humid air climbs a topographic slope
  - ***Evaporation fog*** – results when water vapor is added to cold air that is already near saturation.
- The ***foggiest areas in the US are the Pacific, New England and the Atlantic Canada coasts, and the valleys and hills of the Appalachians***
- ***Dense fog contributes to numerous accident, injuries, and deaths each year***

Drought & Mountain Windstorms

- ***Hazards created by wind and lack of rain***
  - **Drought**
    - ***Extended period of unusually low precipitation*** that produces a temporary shortage of water for people, other animals, and plants
    - More than ***1 billion people around the world live in arid areas***
      - Contribute to food shortages-causes famine
      - Water shortages
      - Power shortages
      - Decrease in industrial productivity
  - **Mountain Windstorms**
    - ***Strong winds, usually in the winter, which blow down the downward sides of mountains***
      - Much like our "***east winds***" when we have a high pressure to the northeast of Utah

Dust and Sand Storms, Heat Waves

- ***Hazards created by wind and lack of rain***
  - ***Dust and Sand Storms***
    - Strong windstorms carrying suspended dust causing low visibility for a long period of time
  - ***Heat Waves***
    - Prolonged periods of extreme heat
      - Both longer and hotter than the year before
      - Happen under prolong high pressures
      - Responsible for many deaths from 1992 on

Dust Storms of the 1930s

(a)

Human Interaction with Weather

- Many **natural hazards** are ***clearly and significantly altered by human activities***
  - We have seen:
    - ***How land use affect flooding and landslides***
    - ***How deep-well disposal and the filling of large water reservoirs may contribute to earthquakes***
    - ***How bad farming practices of leaving exposed topsoil lead to the dust bowl situations like in the 1930***
    - ***Locating mobile homes in areas subject to frequent high winds and tornadoes increases damages and loss of life***
    - ***Land-use practices in cities can intensify the effects of heatwaves***
    - ***On a larger scale, human interaction with severe weather is taking place through global warming***

Linkages with Other Hazards

- ***Severe weather is linked to other hazards***
  - **Flooding , often flash floods**
  - **Lightening**
  - **Mass land movements**
  - **Wildfires**
  - **Long-term global climate change**

Natural Service Functions of Severe Weather

- There are some ***natural service functions of severe weather***
  - There are ***long term services***
    - ***Lightening from a thunderstorm can start a wildfire, which can revitalize a forest or prairie***
    - ***Windstorms can help maintain the health of forests***
    - ***Ice storms are a natural ecological cycle that increases plant and animal diversity in the forest***
  - In the ***hydrological cycle, severe weather are a primary source of water***
  - Humans can benefit from severe weather by ***enjoying a lightening show, watching a snowstorm, and watch a tornado chaser in a movie describe how they can be dumb being in the middle of a tornado***

Minimizing Severe Weather Hazards

- ***Severe weather will continue to threaten humans*, because we can't "fix stupid"**
- **But if we as humans work at it, *we can minimize the damage and loss of life associated with them***
- ***We must be able to predict these events accurately in order to reduce their hazard***

Forecasting and Predicting Weather Hazards

- ***Timely and accurate prediction of severe weather events is extremely important if human lives are to be spared***
- ***Even with improvements in satellite sensors and computer modeling, we still have difficulty forecasting severe weather***
- **The *behavior of these events are unpredictable***

- **Many of the new ways to *forecast and predict* the weather have become more and available:**
  - **The *use of the Doppler Radar*** stations are used to predict severe weather
  - ***Watches and Warnings*** are posted for severe weather-if followed there can be less damage and loss of life
  - All of these ***new prediction abilities*** can predict the severe weather, but humans have to be aware of their surroundings and act accordingly

Adjustment to the Severe Weather Hazard

- ***Although we can't control the weather or the climate, there are two ways we can reduce the loss of life and property***
  - These actions include both long-term changes to community infrastructure and plans or procedures to be implemented for severe weather
  - Long-term actions to prevent or minimize death, injuries, and damage is considered ***mitigation***
  - Establishing community and individual plans and procedures to deal with impending natural hazard is considered ***preparedness***

Adjustment to the Severe Weather Hazard

- **Mitigation activities**
  - ***Using safety-conscious engineering in building structures***
  - ***Installing warning systems***
  - ***Establishing hazard insurance***

- **Preparedness and Personal Adjustments**
  - ***Establishing community and individual plans and procedures to deal with an impending natural hazard***